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| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|-----------------|-------------|----------------------|---------------------|------------------|
|-----------------|-------------|----------------------|---------------------|------------------|

10/593,178

01/05/2007

Wolfgang Schlegel

03528.0151.PCUS00

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02/18/2009

HOWREY LLP-CA

C/O IP DOCKETING DEPARTMENT

2941 FAIRVIEW PARK DRIVE, SUITE 200

FALLS CHURCH, VA 22042-2924

EXAMINER

TANINGCO, ALEXANDER H

ART UNIT

PAPER NUMBER

2882

MAIL DATE

DELIVERY MODE

02/18/2009

PAPER

**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

|                              |  |  |  |
|------------------------------|--|--|--|
| <b>Office Action Summary</b> | <b>Application No.</b><br>10/593,178     | <b>Applicant(s)</b><br>SCHLEGEL ET AL. |  |
|                              | <b>Examiner</b><br>ALEXANDER H. TANINGCO | <b>Art Unit</b><br>2882                |  |

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

### Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

### Status

- 1) ☒ Responsive to communication(s) filed on 14 September 2006.
- 2a) ☐ This action is **FINAL**.                      2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

### Disposition of Claims

- 4) ☒ Claim(s) 1-34 is/are pending in the application.
- 4a) Of the above claim(s) \_\_\_\_\_ is/are withdrawn from consideration.
- 5) ☐ Claim(s) \_\_\_\_\_ is/are allowed.
- 6) ☒ Claim(s) 1-34 is/are rejected.
- 7) ☐ Claim(s) \_\_\_\_\_ is/are objected to.
- 8) ☐ Claim(s) \_\_\_\_\_ are subject to restriction and/or election requirement.

### Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☒ The drawing(s) filed on 14 September 2006 is/are: a) ☒ accepted or b) ☐ objected to by the Examiner.  
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).  
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

### Priority under 35 U.S.C. § 119

- 12) ☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☒ All    b) ☐ Some \*    c) ☐ None of:
1. ☒ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

\* See the attached detailed Office action for a list of the certified copies not received.

### Attachment(s)

- |  |   |
|--|---|
| 1) <input checked="" type="checkbox"/> Notice of References Cited (PTO-892)            | 4) <input type="checkbox"/> Interview Summary (PTO-413)           |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948)   | Paper No(s)/Mail Date. _____                                      |
| 3) <input checked="" type="checkbox"/> Information Disclosure Statement(s) (PTO/SB/08) | 5) <input type="checkbox"/> Notice of Informal Patent Application |
| Paper No(s)/Mail Date <u>01/05/2007</u> .  | 6) <input type="checkbox"/> Other: _____                          |

## **DETAILED ACTION**

### ***Claim Objections***

Claims 1, 6, and 20 are objected to because of the following informalities, which appear to be minor draft errors including grammatical and/or lack of antecedent problems:

In Claim 1, line 1, delete "(37)"; line 2, delete "(53)" and "(58)"; line 3, delete "(37)"; line 5, delete "(2)"; line 6, delete "(62, 63, 64, 65)"; line 8, delete "(50)"; line 9, delete "(70)"; line 10, delete "(38, 39, 40, 41)"

In Claim 6, line 2, "a pixel is stored in is selected ", was claimed perhaps - - a pixel is stored by a - - was meant

In Claim 20, line 1, delete "(53)"; line 2, delete "(58)"; line 5, delete "(62, 63, 64, 65)"; line 7, delete "(50)"; line 8, delete "(38, 39, 40, 41)"

### ***Claim Rejections - 35 USC § 101***

35 U.S.C. 101 reads as follows:

Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor, subject to the conditions and requirements of this title.

Claims 33 and 34 are rejected under 35 U.S.C. 101 because the claimed invention is directed to non-statutory subject matter.

The claims are drawn to a computer program per se. Computer programs per se are abstract instructions. Therefore, a computer program is not a physical thing (product) nor a process as they are not "acts" being performed. As such, these claims

are not directed to one of the statutory categories of invention (See MPEP 2106.01), but are directed to nonstatutory functional descriptive material.

It is noted that computer programs embodied on a computer readable medium, which would permit the functionality of the program to be realized, would be directed to a product and be within a statutory category of invention, so long as the computer readable medium is not disclosed as non-statutory subject matter per se (signals or carrier waves).

### ***Claim Rejections - 35 USC § 103***

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

Claims 1-5, 9, 13, 16-22, 25, and 28-34 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kaufman et al. (US 2004/0125103) in view of Kornmesser et al. (Fast Feldkamp-reconstruction for real-time reconstruction using C-arm-systems).

**With regards to claims 1 and 33**, Kaufman et al. disclose a backprojection unit adapted for backprojecting pixel data of n acquired projections onto a voxel subvolume, with n being a natural number, wherein said backprojection unit comprises for each of the n projections: voxel center determination means adapted for projecting m contiguous voxels onto a respective one of the projections thus obtaining m projected voxel centers per projection [para 0017, 0023-0025]; memory access means **24**

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adapted for fetching, for each of the  $m$  projected voxel centers, pixel data of pixels adjacent to the projected voxel center from a respective projection buffer [para 0025; Fig. 3 and Fig. 4]; multiplexing means adapted for distributing the fetched pixel data to  $m$  different pipelines [para 0017; 0392].

Kaufman et al. fail to explicitly teach  $m \geq 2$  being a natural number. Kornmesser et al. teach voxel center determination means adapted for projecting  $m$  contiguous voxels onto a respective one of the projections, with  $m \geq 2$  being a natural number, thus obtaining  $m$  projected voxel centers per projection (page 432 Line 14 – page 433 Line 19).

It would have been obvious to one of ordinary skill in the art, at the time of invention to modify the invention of Kaufman et al. to include the features of Kornmesser et al., since one would have been motivated to make such a modification to improve computational speed as taught by Kornmesser et al. (Abs.).

**With regards to claim 2**, Kaufman et al. as modified above disclose  $n$  projection buffers, with each of the projection buffers being adapted for storing pixel data of one of the  $n$  projections [para 0017; 0123-0125].

**With regards to claim 3**, Kaufman et al. as modified above disclose wherein each of the projection buffers comprises at least  $(2m+2)$  different memory banks [para 0123; Fig. 3-Fig. 4].

**With regards to claim 4**, Kaufman et al. as modified above disclose wherein the memory access means are adapted for accessing some of the at least  $(2m+2)$  memory banks of the corresponding projection buffer in parallel [para 0133; 0486].

**With regards to claim 5**, Kaufman et al. as modified above disclose wherein pixel data of neighboring pixels are stored in different memory banks [para 0125].

**With regards to claim 9**, Kaufman et al. as modified above disclose wherein at least one of the pipelines comprises: pixel data interpolation means adapted for performing a bilinear interpolation of the pixel data of pixels adjacent to a respective projected voxel center, in order to obtain an interpolated pixel value at the respective projected voxel center [para 0010; Fig. 5].

**With regards to claim 13**, Kaufman et al. as modified above disclose wherein voxel data of the m contiguous voxels is stored in storage cells of m shift registers, said shift registers being adapted for accumulating the contributions of the n projections [para 0388].

**With regards to claim 16**, Kaufman et al. as modified above disclose wherein the voxel subvolume is a slice of a voxel volume [para 0016].

**With regards to claim 17**, Kaufman et al. as modified above disclose wherein the slices are oriented perpendicular to an axis of rotation that has been used for acquiring the projections [para 0029].

**With regards to claim 18**, Kaufman et al. as modified above disclose wherein a voxel volume is initially segmented into a plurality of columns, with each voxel subvolume being a slice of a respective column [para 0124 and 0197].

**With regards to claim 19**, Kaufman et al. as modified above disclose wherein the backprojection unit is implemented as a hardware unit, in particular by means of a Field Programmable Gate Array (FPGA) (Abs. Kornmesser et al.).

**With regards to claims 20 and 34**, Kaufman et al. discloses a method for backprojecting pixel data of  $n$  acquired projections onto a voxel subvolume, with  $n$  being a natural number, the method comprising the following steps that are carried out for each of the  $n$  projections: fetching, for each of the  $m$  projected voxel centers, pixel data of pixels adjacent to the projected voxel center from a respective projection buffer, and distributing the fetched pixel data to  $m$  different pipelines [para 0017, 0023-0025, 0392]. Kaufman et al. fails to explicitly teach projecting  $m$  contiguous voxels onto a respective one of the projections, with  $m \geq 2$  being a natural number, thus obtaining  $m$  projected voxel centers per projection.

Kornmesser et al. teach voxel center determination means adapted for projecting  $m$  contiguous voxels onto a respective one of the projections, with  $m \geq 2$  being a natural number, thus obtaining  $m$  projected voxel centers per projection (page 432 Line 14 – page 433 Line 19). It would have been obvious to one of ordinary skill in the art, at the time of invention to modify the invention of Kaufman et al. to include the features of Kornmesser et al., since one would have been motivated to make such a modification to improve computational speed as taught by Kornmesser et al. (Abs.).

**With regards to claim 21**, Kaufman et al. as modified above discloses wherein the pixel data of the  $n$  projections are stored in  $n$  separate projection buffers [para 0017; 0123-0125].

**With regards to claim 22**, Kaufman et al. as modified above discloses wherein the step of fetching comprises accessing at least some of the at least  $(2m+2)$  memory banks in parallel [para 0123; Fig. 3-Fig. 4].

**With regards to claim 25**, Kaufman et al. as modified above discloses a step of performing a bilinear interpolation of the pixel data of pixels adjacent to a respective projected voxel center, in order to obtain an interpolated pixel value at the respective projected voxel center [para 0010; Fig. 5].

**With regards to claim 28**, Kaufman et al. as modified above discloses a step of accumulating the contributions of the n projections by means of m shift registers, whereby each of the m shift registers comprises n storage cells that correspond to the n different projections [para 0388].

**With regards to claim 29**, Kaufman et al. as modified above discloses a step of shifting the contents of the m shift registers by one position, after voxel data stored in the m shift registers has been updated, in order to consecutively process the contributions of the n different projections [para 0388].

**With regards to claim 30**, Kaufman et al. as modified above discloses wherein slices of a voxel volume are chosen as voxel subvolumes, with the slices being oriented perpendicular to an axis of rotation that has been used for acquiring the projections [para 0016].

**With regards to claim 31**, Kaufman et al. as modified above discloses a step of initially segmenting a voxel volume into a plurality of columns, with slices of said columns being chosen as voxel subvolumes [para 0124 and 0197].

**With regards to claim 32**, Kaufman et al. as modified above discloses wherein a separate backprojection is performed for each slice of the column [para 0509].



Claims 6 and 7 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kaufman et al. (US 2004/0125103) and Kornmesser et al. (Fast Feldkamp-reconstruction for real-time reconstruction using C-arm-systems) as applied to claim 1 above, and further in view of Roberson et al. (US 5,566,341).

**With regards to claims 6 and 7**, Kaufman et al. as modified above discloses a method as recited above in claim 1. Kaufman et al. discloses 2D mapping and data having a location lying on a grid point [para 0019 and 0024]; dataset with index numbers and pixels stored in the corresponding 2D memory unit [para 0116, 0133, 0164, and 0195]. Kaufman et al. fails to explicitly teach a multidimensional index. Roberson et al. teaches a multidimensional index (Abs.). It would have been obvious to one of ordinary skill in the art, at the time of invention to modify the invention of Kaufman et al. to include the features of Roberson et al., since one would have been motivated to make such a modification to reduce computational bottleneck thus improving computational speed as taught by Roberson et al. (Col. 2 Lines 15-20).

Claim 8 is rejected under 35 U.S.C. 103(a) as being unpatentable over Kaufman et al. (US 2004/0125103), Kornmesser et al. (Fast Feldkamp-reconstruction for real-time reconstruction using C-arm-systems), and Roberson et al. (US 5,566,341) as applied to claim 7 above, and further in view of Winsor (US 5,495,563).

**With regards to claim 8**, Kaufman et al. as modified above disclose an apparatus as recited above in claim 7. Kaufman et al. discloses a modulo operation [para 0099]. However, Kaufman et al. fail to explicitly teach wherein, for  $m = 4$ , the two dimensional index  $(u, v)$  is determined as  $(u, v) = (x \bmod 5, y \bmod 2)$ . Winsor teaches a

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modulation value MOD is available for each pixel location being addressed (Col. 7 Lines 35-45). It would have been obvious to one of ordinary skill in the art, at the time of invention to modify the invention of Kaufman et al. to include a method of partitioning pixel data as taught by Winsor, since one would have been motivated to make such a modification to improve mapping as taught by Winsor (Col. 7 Lines 1-3).

Claims 10-12, 14, and 15 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kaufman et al. (US 2004/0125103) and Kornmesser et al. (Fast Feldkamp-reconstruction for real-time reconstruction using C-arm-systems) as applied to claim 9 above, and further in view of Taguchi et al. (US 5,838,756).

**With regards to claim 10**, Kaufman et al. as modified above disclose an apparatus as recited above in claim 9. Kaufman et al. disclose calculating a distance between a voxel to the source [para 0021]. Kaufman et al. fails to explicitly teach wherein at least one of the pipelines further comprises: a weighting unit adapted for weighting the interpolated pixel value at the projected voxel center with the inverse square of the distance between voxel and source, in order to obtain a weighted pixel value at the projected voxel center.

Taguchi et al. teach wherein at least one of the pipelines further comprises: a weighting unit adapted for weighting the interpolated pixel value at the projected voxel center with the inverse square of the distance between voxel and source, in order to obtain a weighted pixel value at the projected voxel center (Col. 1 Lines 40-50). It would have been obvious to one of ordinary skill in the art, at the time of invention to modify the invention of Kaufman et al. to include a distance weighting as taught by

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Taguchi et al., since one would have been motivated to make such a modification to improve imaging as implied by Taguchi et al. (Col. 1 Lines 40-50).

**With regards to claim 11**, Kaufman et al. as modified above disclose wherein at least one of the pipelines further comprises: an adder unit adapted for adding the weighted pixel value at the projected voxel center to voxel data of the corresponding one of the m contiguous voxels [para 0021-0022].

**With regards to claim 12**, Kaufman et al. as modified above disclose wherein the weighted pixel values are added to the contents of storage cells that belong to m different shift registers [para 0388].

**With regards to claim 14**, Kaufman et al. as modified above disclose wherein each of the m shift registers comprises n storage cells that correspond to the n different projections [para 0388].

**With regards to claim 15**, Kaufman et al. as modified above disclose wherein, after voxel data stored in the m shift registers has been updated, the contents of the shift registers are shifted by one position in order to consecutively process the contributions of the n different projections [para 0388].

Claims 23 and 24 rejected under 35 U.S.C. 103(a) as being unpatentable over Kaufman et al. (US 2004/0125103) and Kornmesser et al. (Fast Feldkamp-reconstruction for real-time reconstruction using C-arm-systems) as applied to claim 20 above, and further in view of Roberson et al. (US 5,566,341).

**With regards to claims 23 and 24**, Kaufman et al. as modified above discloses a method as recited above in claim 20. Kaufman et al. discloses 2D mapping and data

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having a location lying on a grid point [para 0019 and 0024]; dataset with index numbers and pixels stored in the corresponding 2D memory unit [para 0116, 0133, 0164, and 0195]. Kaufman et al. fails to explicitly teach a multidimensional index. Roberson et al. teaches a multidimensional index (Abs.). It would have been obvious to one of ordinary skill in the art, at the time of invention to modify the invention of Kaufman et al. to include the features of Roberson et al., since one would have been motivated to make such a modification to reduce computational bottleneck thus improving computational speed as taught by Roberson et al. (Col. 2 Lines 15-20).

Claims 26 and 27 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kaufman et al. (US 2004/0125103), Kornmesser et al. (Fast Feldkamp-reconstruction for real-time reconstruction using C-arm-systems), and Roberson et al. (US 5,566,341) as applied to claim 25 above, and further in view of Taguchi et al. (US 5,838,756).

**With regards to claim 26**, Kaufman et al. as modified above disclose an apparatus as recited above in claim 25. Kaufman et al. disclose calculating a distance between a voxel to the source [para 0021]. Kaufman et al. fails to explicitly teach wherein at least one of the pipelines further comprises: a weighting unit adapted for weighting the interpolated pixel value at the projected voxel center with the inverse square of the distance between voxel and source, in order to obtain a weighted pixel value at the projected voxel center.

Taguchi et al. teach wherein at least one of the pipelines further comprises: a weighting unit adapted for weighting the interpolated pixel value at the projected voxel

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center with the inverse square of the distance between voxel and source, in order to obtain a weighted pixel value at the projected voxel center (Col. 1 Lines 40-50). It would have been obvious to one of ordinary skill in the art, at the time of invention to modify the invention of Kaufman et al. to include a distance weighting as taught by Taguchi et al., since one would have been motivated to make such a modification to improve imaging as implied by Taguchi et al. (Col. 1 Lines 40-50).

**With regards to claim 27**, Kaufman et al. as modified above disclose wherein at least one of the pipelines further comprises: an adder unit adapted for adding the weighted pixel value at the projected voxel center to voxel data of the corresponding one of the m contiguous voxels [para 0021-0022].

### ***Conclusion***

The prior art made of record and not relied upon is considered pertinent to applicant's disclosure. The following patents are cited to further show:

**Dzmitry et al. (Real-Time 3D Cone Beam Reconstruction)** shows implementing a backprojection algorithm on a field programmable gated array (page 3648).

**Hosinger et al. (US 6,278,791)** shows a modulo-N simulator (Col. 5 Lines 59-65)

**Karron et al. (US 5,898,793)** shows step of forming triangles is repeated for each pair of voxel face intersects on the six faces of the voxel. The physical location of the third vertex of each triangle is identical and is computed as the centroid of all interpolated intersect coordinate values for the voxel (Abs.).

**Ray et al. (US 6,664,961)** shows regular and predictable memory accessing, fully pipelined processing and space leaping and buffering of voxels to eliminate voxel-refetch (Abs.).

**Wang et al. (US 5,769,789)** shows image volume is first searched for "seed points", which are candidate voxels that lie within candidate (i.e., potential) markers. Next, the region around each candidate voxel (in the original image) is examined to discard false positives from the set of candidate voxels and to determine their centroids more precisely (Abs.).

**Hwang et al. (US 6,775,401)** shows a spatial location between the centers of two adjacent voxels would be computed as the average of the two voxels (Abs.).

**Kaufman et al. (US 6,674,430)** shows Each of the plurality of rendering pipelines is vertically coupled to both a corresponding one of the plurality of 3D memory units and the at least first pixel bus, and each of the rendering pipelines has global horizontal communication preferably with at most its two nearest neighbors. The rendering pipelines receive voxel data from the corresponding 3D memory units and generate a two-dimensional (2D) base plane image aligned with a face of the volume dataset (Abs.).

Any inquiry concerning this communication or earlier communications from the examiner should be directed to ALEXANDER H. TANINGCO whose telephone number is (571)272-8048. The examiner can normally be reached on Mon-Fri 8:00-4:30 EST.

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If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Ed Glick can be reached on (571) 272-2490. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Alexander H Taningco/  
Examiner, Art Unit 2882

/Allen C. Ho/  
Primary Examiner, Art Unit 2882